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Studies on the microflora of Danish beech forest soils

V. The microfungi

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The present paper contains quantitative and qualitative observations on microfungi occurring in beech mull and beech mor soils. Descriptions of the localities investigated are given in a previous paper (V. JENSEN 1963 a).

Strictly speaking, all talk of "numbers" of fungi per gm. of soil is irrational, because the soil fungi do not exist as well-defined individuals. When, nevertheless, this term is used in the following for the sake of convenience, the actual meaning is the number of fungal colonies arising under the given circumstances, calculated per gm. of dry soil.

Excellent reviews and discussions of the methods for isolation and estimation of the activity of fungi in soil have been recently published by BURGES (1958) and WARCUP (1960). At present the problem can be summarized briefly as follows:

The dilution plate count is the method most widely used, and it has given much valuable information on the soil fungi. However, it has certain disadvantages and limitations, the most important probably being the impossibility of discerning actively growing mycelium from resting spores. The dessication method of MCLENNAN (1928) has been shown by WARCUP to be definitely inadequate for this purpose (WARCUP 1960).

Most of the colonies on dilution plates usually have developed from spores, and therefore the heavily sporing fungi are predominant on the plates, whereas many fungus species, known to occur in the soil, seldom or never appear.

A great many other methods have been proposed to overcome these difficulties, but none of them are entirely satisfactory. The hyphal isolation technique of WARCUP (1955) is perhaps the most promising, but it is a difficult and laborious technique, and, furthermore, mainly qualitative. Methods for direct microscopic estimation of the amount of mycelium in the soil have also been described, but are little used.

The results recorded in the following are based mainly on dilution plate counts and isolations therefrom. The details of this technique have been discussed in a previous paper (V. JENSEN 1962), and no further comments shall be given here except for brief accounts of the actual methods used.

Numbers of fungi

Series I (1955—1958)

Technique: On each locality subsamples were drawn at a number of points, usually 5—8, and then mixed to a composite sample. Sterile spoons of stainless steel were used, and the samples were placed in sterile glass vessels with tight-fitting screw caps. The mull samples represent the upper 5 cm. of the mull layer, and the mor samples the entire mor layer.

The samples were drawn in the morning, and the dilution plates were poured within a few hours after sampling. The samples were thoroughly mixed, and 10 gm. portions were transferred to 300 ml. Erlenmeyer flasks containing 100 ml. sterile water, and the flasks shaken vigorously for 10 minutes, using a mechanical shaker. The coarsest particles were allowed to settle, and a series of dilutions were prepared from the supernatant suspension by serial transfers of 5 ml. to 45 ml. sterile salt solution (WINOGRADSKY's standard salt solution 1 : 20). 5—8 plates were poured from the dilution $1 : 10^4$, each inoculated with 1 ml. of the dilution.

Two different plating media were used: the synthetic glucose asparagine salts agar of H. L. JENSEN (1931) and malt extract agar prepared from 2 per cent commercial malt extract and 2 per cent agar in tap water, pH about 5.

The colonies were counted after incubation for 4—5 days at 25° C. The number of colonies generally ranged from 10 to 50 per plate, and a considerable variation occurred between the individual plates, up to $\pm$ 50 per cent of the average value.

The moisture content of the soil samples was determined by drying at 100—105° C to constant weight, and the pH by means of the glass electrode in 1 : 1 mixtures of fresh soil and distilled water.

The results of this series of experiments are recorded in tables 1 and 2. Since the fungal counts cannot be expected to express the actual growth activity at the moment of sampling, a direct comparison between fluctuations in physico-chemical properties of the soil and the fungal numbers is futile. Only the general level of the numbers will be considered in the present paper.

The difference between the two plating media is small and hardly significant. In a number of cases the same soil samples were plated on both media, and when these samples only are considered, the synthetic glucose agar gave results varying from 59.000 to 953.000 per gm. of soil with an average value of 432.000, and the malt extract agar values from 78.000 to 1.144.000 per gm. with an average of 415.000.

The results indicate that the numbers of fungi per gm. of dry soil are about four times higher in the mor than in the mull soils. However, when the numbers per gm. of organic matter are calculated, the average numbers are of the same order of magnitude in the two soil types. When comparisons are made between samples drawn on the same date (see table 3) it appears that the mull soils in almost all cases contain considerably higher numbers of fungi per gm. of organic matter than the mor soils. The reverse occurred on only one occasion (3. 5. 1956), where the highest number found in the mor soils coincides with the next lowest number from the mull soils.

Unfortunately, the experiments do not allow calculations of the numbers of fungi in the entire profile per areal unit. According to ROMELL (1932) the total amount of organic matter in the profile is generally as large or larger in mull than in mor soils. If the numbers of fungi per gm. of organic matter is approximately constant throughout the profile, this would mean that the total number of fungi per areal unit is about the same in the two soil types or even higher in the mull

Table 1

Series I. Fungal counts on synthetic glucose asparagine salts agar

Locality	Date	pH	Moisture % of d. m..	Fungal counts thousands per gm. of dry soil	Fungal counts thousands per gm. of org. matter
I	27. 5. 1955	5.1	35	125	1136
	19. 8. 1955	5.3	20	130	1182
	10. 11. 1955	5.3	54	386	3509
	13. 4. 1956	5.1	45	325	2954
III	19. 8. 1955	5.2	25	125	1157
	10. 11. 1955	5.2	70	274	2537
	3. 5. 1956	—	54	89	824
VI	19. 8. 1955	5.7	45	72	766
	10. 11. 1955	5.7	52	157	1670
	3. 5. 1956	6.9	39	59	628
VII	6. 4. 1957	5.4	37	185	1595
X	6. 4. 1957	4.7	56	104	654
average of mull soils:				169.3	1551.0
II	27. 5. 1955	4.2	133	319	829
	19. 8. 1955	4.1	47	258	670
	10. 11. 1955	4.1	104	535	1390
	13. 4. 1956	4.5	104	441	1145
IV	19. 8. 1955	4.0	64	311	920
	10. 11. 1955	4.4	117	581	1719
	3. 5. 1956	4.7	104	819	2423
V	19. 8. 1955	4.6	37	549	1369
	10. 11. 1955	4.5	133	834	2080
	3. 5. 1956	—	117	547	1364
VIII	6. 4. 1957	4.4	163	800	1262
IX	6. 4. 1957	4.3	213	953	1298
average of mor soils:				578.9	1372.4

than in the mor soils, contrary to the general presumption (cf. V. JENSEN 1963 a, p. 369).

A few samples of mineral soil from a depth of 35 cm. below surface were analyzed for comparison with the following results:

Table 2

Series I. Fungal counts on malt extract agar

Locality	Date	pH	Moisture % of d. m.	Fungal counts thousands per gm. of dry soil	Fungal counts thousands per gm. of org. matter
I	13. 4. 1956	5.1	45	258	2345
	3. 7. 1958	4.5	25	120	1644
III	3. 5. 1956	—	54	119	1102
	2. 12. 1958	4.7	43	54	535
VI	3. 5. 1956	6.9	39	78	830
	5. 5. 1958	5.3	52	217	1476
VII	6. 4. 1957	5.4	37	184	1586
X	6. 4. 1957	4.7	56	120	755
average of mull soils:				143.8	1284.1
II	13. 4. 1956	4.5	104	260	675
	3. 7. 1958	3.8	113	345	800
IV	3. 5. 1956	4.7	104	1144	3385
	2. 12. 1958	4.2	144	150	369
V	3. 5. 1956	—	117	526	1312
	5. 5. 1958	4.5	122	459	1224
VIII	6. 4. 1957	4.4	163	580	915
IX	6. 4. 1957	4.3	213	877	1195
average of mor soils:				542.6	1234.4

Locality I (mull) . . . 3.000 fungi per gm. of dry soil
Locality III (mull) . . . 12.500 fungi per gm. of dry soil
Locality II (mor) . . . 14.000 fungi per gm. of dry soil
Locality IV (mor) . . . 4.800 fungi per gm. of dry soil

At this depth the organic matter content was very low, and the fungi very few in number compared with the corresponding surface soils. The results do not indicate any difference between the two soil types.

Series II (1961—1962)

This series comprises plate counts on 6 series of soil samples drawn from the localities I, II, III and IV with intervals of about 2 months, thus covering a period of one year. The technique was the same as in series I, except for the following modifications:

Table 3

Series I. Fungal counts arranged according to sampling date

Date	Average numbers in thousands per gm. of dry soil		per gm. of org. matter	
	mull	mor	mull	mor
27. 5. 1955	125	319	1136	829
19. 8. 1955	109	373	1035	986
10. 11. 1955	272	650	2572	1730
13. 4. 1956	292	351	2650	910
3. 5. 1956	86	759	846	2121
6. 4. 1957	148	803	1148	1168
5. 5. 1958	217	459	1476	1224
3. 7. 1958	120	345	1644	800
2. 12. 1958	54	150	535	369
weighed average	159.1	564.4	1444.1	1317.2

The 10 minutes' shaking of the first suspension was replaced by trituration in a mortar followed by 5 minutes' mechanical shaking. The trituration is of special importance for fungal counts, because immediate pipetting is then possible. When the suspension is shaken only, settling of the coarser particles is necessary, and most of the fungous mycelium present will settle with the soil and humus particles and only spores will remain in suspension.

Two different dilutions (1 : 20.000 and 1 : 50.000) were used for the platings, prepared as follows: 5 ml. of the original suspension (1 : 10) were transferred to 500 ml. sterile tap water, making the dilution 1 : 1000. From this dilution 5 ml. were transferred to 100 ml. sterile tap water (1 : 20.000) and other 5 ml. to 250 ml. sterile tap water (1 : 50.000). Thus, both dilutions were prepared by means of only two pipettings.

The dextrose peptone yeast extract agar (DPYA) of PAPAVIZAS and DAVEY (1959) was used as plating medium. It contains several inhibiting substances: streptomycin, aureomycin, ox-gall and sodium propionate. Bacterial growth is completely inhibited, and both sporulation and spreading growth of the fungi present are restricted considerably, thus allowing a longer incubation period. In the present experiments the plates were incubated for 7—8 days at 25° C.

Two entirely independent plate counts were made on each soil sample, allowing an estimation of the reliability of the results obtained.

The results are recorded in table 4. The numbers of fungi in this series are about four times higher than the corresponding numbers in series I, an increase which must be attributed to the amended technique. The trituration of the soil will increase the number of colonies on the plates, and the inhibiting substances in the plating medium will prevent the slow-growing fungi from being overgrown by bacteria or spreading fungi. The longer incubation period also allows more of the slowgrowing fungi to form visible colonies. The experiments show that extreme cautiousness must be exercised when results from different experimental series are compared, even if only small technical changes have been introduced.

In spite of the large increase in the general level of the numbers, the ratio between mull and mor soils is about the same as in series I, i. e. 3—4 times higher numbers per gm. of dry soil in mor than in mull soils. The results give no indications of regular seasonal fluctuations. The changes in the numbers from time to time seem to be merely incidental.

Table 4

Series II. Fungal counts on DPYA medium. Localities I and III are mull soils, II and IV mor soils

Locality	Date	pH	Moisture % of d. m.	Fungal counts thousands per gm. of dry soil 1	2
I	16. 3. 1961	5.1	42	829	868
	2. 6. 1961	5.0	41	607	529
	8. 8. 1961	5.0	39	618	678
	27. 9. 1961	4.8	36	908	787
	5. 12. 1961	5.1	43	669	688
	1. 2. 1962	5.0	46	1089	1752
			average:	835.2	
III	22. 3. 1961	5.3	47	561	681
	29. 5. 1961	4.9	35	695	588
	11. 8. 1961	5.0	40	836	703
	28. 9. 1961	4.9	23	731	610
	8. 12. 1961	5.1	53	702	950
	2. 2. 1962	4.7	52	424	326
			average:	650.6	
II	17. 3. 1961	4.1	151	2283	2383
	2. 6. 1961	4.1	143	2003	2051
	8. 8. 1961	3.9	149	3241	2945
	27. 9. 1961	3.8	162	5037	4337
	5. 12. 1961	3.8	138	2700	2569
	1. 2. 1962	3.9	109	2367	2812
			average:	2894.0	
IV	23. 3. 1961	4.1	255	2103	2220
	29. 5. 1961	4.2	81	1162	1360
	11. 8. 1961	3.8	124	1682	1665
	28. 9. 1961	3.9	133	1679	1630
	8. 12. 1961	4.0	110	2294	2237
	2. 2. 1962	4.0	135	1337	1191
			average:	1713.3	

Composition of the fungus flora

Observations, based on dilution plates

After counting of the colonies on the dilution plates, a number of these colonies were transferred to culture tubes with glucose asparagine agar (see LILLY and BARNETT 1951, p. 427). As far as possible, transfers were made from all colonies

on a number of plates in order to secure a correct representation of the genera present. After a suitable incubation period, the cultures were examined and identified as to genus, and representatives of all occurring types were set aside for species identification and further studies.

The results of the preliminary classification are summarized in table 5.

The percentage of *Phycomycetes* is practically the same in mull and in mor soils. About 25 per cent of the colonies on the synthetic glucose agar, about 17 per cent of the colonies on malt extract agar, and about 8 per cent of the colonies on DPYA belong to this group. The genera *Mucor* and *Absidia* were found only rarely on the dilution plates, although their common occurrence was proved by other isolation methods (see below, p. 175–176), a fact indicating a very sparse sporulation in the soil. The great majority within this group were members of the genus *Mortierella* (including *Mortierella ramanniana* [Möller] Linnemann). The group labelled "other *Phycomycetes*" contains a few very slow-growing cultures from the DPYA plates with a typical phycomycetous mycelium and sporangia-like structures.

Ascomycetes, including the ascosporogenous members of the genus *Penicillium*, were observed very occasionally on the dilution plates and seem to be of rare occurrence in these soils. The same observation was made by WARCUP (1951), who also found very few *Ascomycetes* in deciduous woodland soils, even when selective methods were used.

By far the largest group of fungi both in beech mull and beech mor, as well as in most other soils, is the *Deuteromycetes* or Fungi imperfecti, constituting almost 80 per cent of the colonies on malt extract agar, and 65—70 per cent of the colonies on the other two media.

Within the *Deuteromycetes* only members of the families *Moniliaceae* and *Dematiaceae* are of common occurrence. The genus *Penicillium* is the most common of all the genera present, followed by *Trichoderma*, *Monilia* and *Verticillium*. A clear difference between mull and more soils is seen here: the penicillia constitute a considerably higher percentage, and most of the remaining genera within the *Moniliaceae* constitute a correspondingly lower percentage of the colonies from mor soils than of the colonies from mull soils. A difference is also found in the occurrence of the *Dematiaceae*, the genera belonging to this family being proportionally more frequent in mull than in mor soils.

For the sake of convenience, the yeasts and yeast-like fungi are placed in a separate group in spite of their belonging to the *Ascomycetes* and *Deuteromycetes*. This group has been treated in a previous paper (V. JENSEN 1963 c), and no further comments shall be given here.

The sterile mycelia were isolated only occasionally from the malt extract agar and the synthetic glucose agar, whereas they constituted an important part of the colonies on DPYA. The main reason for this, however, is probably not the plating medium, but the preparation of the soil suspensions (see p. 171). Both sterile mycelia and sparsely sporulating fungi are much better represented among the transfers from the plate count series II (DPYA) than among those from the plate count series I (malt extract agar and synthetic glucose agar). The total percentage of sterile mycelia is almost twice as high in mor as in mull soils.

The composition of the fungus flora of the subsoils differs strikingly from that of the corresponding surface soils. The genus *Mortierella* was found to be

Table 5
Composition of the fungus flora of beech mull.

	Beech mull					
	Malt extract agar		Synth. gluc. agar		DPYA	
	total	%	total	%	total	%
Phycomycetes						
Mucorales: Absidia	6	2.0	5	2.6	8	0.7
Mucor	0	0.0	3	1.6	0	0.0
Mortierella	46	15.3	41	21.5	96	8.0
other *Phycomycetes* . .	0	0.0	0	0.0	12	1.0
Ascomycetes						
Plectascales	1	0.3	3	1.6	2	0.2
Deuteromycetes						
Sphaeropsidales	0	0.0	1	0.5	6	0.5
Moniliales: Monilia	11	3.7	10	5.3	146	12.1
Cephalosporium .	3	1.0	3	1.6	21	1.7
Trichoderma . .	58	19.2	31	16.3	166	13.8
Penicillium . . .	105	34.8	54	28.4	200	16.6
Pachybasium . .	35	11.6	4	2.1	22	1.8
Verticillium . . .	4	1.3	1	0.5	98	8.1
other *Moniliaceae* . . .	4	1.3	8	4.2	60	5.0
Pullularia . . .	5	1.7	2	1.1	24	2.0
Synsporium . . .	8	2.6	6	3.1	9	0.7
Stachybotrys . .	2	0.7	0	0.0	3	0.2
Cladosporium . .	1	0.3	2	1.1	5	0.4
other *Dematiaceae* . . .	4	1.3	4	2.1	74	6.2
Stilbaceae	0	0.0	0	0.0	12	1.0
Tuberculariaceae .	1	0.3	0	0.0	12	1.0
Yeasts and yeast-like fungi . . .	3	1.0	10	5.3	56	4.6
Mycelia sterilia: hyalin	4	1.3	2	1.1	135	11.2
dark	0	0.0	0	0.0	13	1.1
No growth	1	0.3	0	0.0	25	2.1
Total:	302		190		1205	

the dominating genus, constituting not less than 81.8 per cent of all the colonies on the plates, and only a few other genera were represented. *Mortierella nana* Linnemann was the dominating species.

Observations based on other isolation methods

Direct inoculation with small soil particles on sterile agar plates were made using a variety of media, a. o. beer wort agar, Sabouraud dextrose agar, malt extract agar, soil extract agar and cellulose agar.

beech mor and beech subsoils, on the basis of transfers from dilution plates

Beech mor						Beech subsoils	
Malt extract agar		Synth. gluc. agar		DPYA		Malt extract agar	
total	%	total	%	total	%	total	%
0	0.0	2	1.0	7	0.6	0	0.0
2	0.6	4	2.0	0	0.0	0	0.0
51	16.1	43	21.7	62	5.2	116	81.8
0	0.0	0	0.0	15	1.3	0	0.0
1	0.3	0	0.0	4	0.3	0	0.0
1	0.3	1	0.5	1	0.1	0	0.0
23	7.3	9	4.6	94	7.8	0	0.0
2	0.6	0	0.0	18	1.5	0	0.0
60	18.9	40	20.3	92	7.6	6	4.2
125	39.3	73	36.9	386	32.2	6	4.2
9	2.8	5	2.5	8	0.7	0	0.0
5	1.6	3	1.5	78	6.5	0	0.0
2	0.6	1	0.5	60	5.0	2	1.4
5	1.6	2	1.0	3	0.3	3	2.1
0	0.0	0	0.0	1	0.1	0	0.0
0	0.0	0	0.0	0	0.0	0	0.0
1	0.3	5	2.5	4	0.3	0	0.0
11	3.5	0	0.0	10	0.8	6	4.2
0	0.0	0	0.0	7	0.6	0	0.0
1	0.3	2	1.0	24	2.0	0	0.0
1	0.3	0	0.0	68	5.7	0	0.0
16	5.0	6	3.0	219	18.3	1	0.7
0	0.0	0	0.0	11	0.9	1	0.7
2	0.6	2	1.0	26	2.2	1	0.7
318		198		1198		142	

Plates prepared in this way were usually covered very rapidly by fast-growing, and spreading fungi, and only a few genera were isolated, including *Absidia*, *Mucor*, *Zygorhynchus*, *Mortierella*, *Trichoderma* and *Penicillium*. No appreciable difference was observed between plates inoculated with mull soil and plates with mor soil.

The genus *Mucor* was the dominating genus on many of the plates, in spite of its very rare occurrence on the dilution plates. The dominating species was *M. hiemalis*, but *M. silvaticus* and the zygosporeforming *M. genevensis* were also common.

Table 6

List of species within the order *Mucorales*, isolated from the investigated localities

	Mull soils					Mor soils				
	I	III	VI	VII	X	II	IV	V	VIII	IX
Absidia glauca	+	+		+		+	+	+		+
— *cylindrospora*						+		+		
Mucor ambiguus	+									
— *genevensis*	+			+		+				
— *hiemalis*	+	+	+	+		+				
— *silvaticus*	+									+
— *varians*	+									
— *foenicola*			+			+				
Mortierella nana	+	+								
— *humicola*				+						
— *pusilla*	+									
— *isabellina*	+	+			+	+	+	+		+
— *ramanniana*	+	+	+	+	+	+	+	+		+
— *vinacea*	+									
— *stylospora*		+	+	+	+				+	
— *verticillata*	+		+							
— *humilis*	+			+		+				
— *zonata*		+					+			
— *minutissima*										+
— *globulifera*					+					
— *pulchella*							+		+	+
— *spinosa*	+									
— *exigua*				+						
— *parvispora*				+		+			+	+
Zygorhynchus vuillemini	+					+				
Number of species	15	7	5	9	4	10	5	4	3	7
total			22					15		

The genera *Absidia* and *Zygorhynchus* also occurred rather often on these plates. The latter genus was detected only by this method. It was never observed on the dilution plates. The remaining genera occurred more sporadically, not because they were absent from any of the soils, but because they were unable to compete with the fast-growing *Mucoraceae* under these circumstances.

In a final experimental series an effort was made to remove the fungus spores from the soil particles by repeated washings with sterile tap water. The washed particles were then placed in sterile Petri dishes and embedded in the DPYA medium. However, this procedure did not greatly change the range of genera occurring. In addition to the genera just mentioned, colonies of *Cephalosporium*, *Cylindrocarpon* and *Fusarium* were observed occasionally. Yeasts also occurred now and then, and sterile mycelia were rather common. These changes, however, may as well have been caused by the change of medium, as by the washing procedure.

Table 7

Preliminary list of genera and species, other than *Mucorales*, isolated from the investigated localities

	Mull soils					Mor soils				
	I	III	VI	VII	X	II	IV	V	VIII	IX
Gymnoascus sp.		+								
Neonectria sp.						+				
Phoma sp.	+	+		+	+	+	+			
Monilia geophila	+	+		+	+	+	+	+	+	+
— sp.	+	+		+	+					+
Cephalosporium sp.	+	+	+	+	+	+	+			+
Trichoderma viride	+	+	+	+	+	+	+	+	+	+
Aspergillus fumigatus			+				+			
— *niger*		+								
— sp.		+								
Penicillium sp.	+	+	+	+	+	+	+	+	+	+
Scopulariopsis sp.	+					+	+			
Gliocladium sp.	+						+			
Sporotrichum sp.	+	+								
Botrytis sp.	+	+					+	+		
Pachybasium sp.	+	+	+	+	+	+	+	+		+
Verticillium sp.	+	+	+	+	+	+	+			
Spicaria sp.	+	+	+				+		+	
Trichothecium roseum				+						
Papularia arundinis								+		
Pullularia pullulans	+	+	+	+	+		+	+		+
Gliomastix sp.	+	+								
Synsporium sp.	+	+		+	+		+			
Stachybotrys sp.	+	+								
Humicola grisea								+		
— sp.	+	+			+	+	+			
Memnoniella echinata		+								
Hormodendrum sp.		+					+			
Cladosporium sp.	+	+	+			+	+	+		
Cordana pauciseptata				+						
Arrotheca sp.		+				+	+			
Tilachlidium sp.							+			
Stysanus sp.		+								
Fusarium sp.						+	+			
Cylindrocarpon sp.	+	+				+	+	+		
Number of genera and species total	20	25	9 30	12	11	12	19	9 24	4	7

Genera and species isolated from the investigated localities

The final identification of the isolated strains has been completed only for the order *Mucorales*. The following references were used: ZYCHA (1935), NAUMOV (1939) and LINNEMANN (1941). The results are presented in table 6. Of the remain-

ing groups only a few of the most easily recognizable species have been identified. Table 7 contains a preliminary list of genera and species, belonging to these groups.

The two tables contain a few species, not mentioned by GILMAN (1957), and therefore probably not previously found in soil: *Mucor foenicola* Naumov, *Mortierella globulifera* Rostrup, *M. pulchella* Linnemann, *Papularia arundinis* (Corda) Fries, and *Cordana pauciseptata* Preuss. However, none of these species were common.

Of course, lists of this kind can never be complete. They will always represent merely a section of the total population, determined more or less by the experimental conditions. Therefore, whether or not a particular species is demonstrated in a certain soil sample will always be somewhat incidental. A detailed discussion of the presence or absence of the single genera and species in the different localities will therefore be of little use.

The number of genera and species demonstrated in a locality, will depend on the number of genera and species actually occurring, but also on the number of samples studied and on the number of isolations from each sample. In the present investigations the main purpose was a comparison between the populations in beech mull and beech mor soils. Care has been taken, therefore, that the two soil types are represented as equally as possible with regard to number of samples and number of isolations. A direct comparison between the total number of genera and species demonstrated in the mull and the mor soils is therefore possible.

The tables 6 and 7 indicate that the fungus flora of the mull soils is considerably richer in genera and species than that of the mor soils, a fact already suggested by the figures in table 5. This is at least true of the section of the population, which is represented in the present investigations. Of the *Mucorales*, 22 species have been demonstrated in the mull soils, and only 15 in the mor soils, and of the genera and species, listed in table 7, 30 were found in the mull soils and only 24 in the mor soils.

Of the microbial groups studied previously, the bacterial flora showed a similar behaviour, the population of the mull soils being much richer in species and more varied than that of the mor soils (V. JENSEN 1963 b). However, the mor soils contained higher numbers of individuals and higher numbers of species of yeasts and yeast-like fungi than the mull soils (V. JENSEN 1963 c).

Summary

Counts of fungi in samples of beech mull and beech mor soils have been made, using different plating media. Malt extract agar and a synthetic glucose agar gave almost the same results: 50.000—400.000 per gm. of the mull soils, and 150.000—1.100.000 per gm. of the mor soils. On DPYA (dextrose peptone yeast extract agar), using a slightly modified technique, considerably higher results were obtained: 500.000—1.800.000 for the mull soils, and 1.200.000—5.000.000 for the mor soils. However, the ratio between mull and mor was approximately the same in both cases: on an average 3—4 times higher numbers per gm. of dry soil in mor than in mull soils.

In order to study the composition of the fungus flora of the two soil types, a total of 3411 strains were isolated and classified (1697 from mull soils and 1714

from mor soils). Furthermore, as a supplement to the dilution plates, a number of different agar media were inoculated directly with soil particles, and the developing fungi studied. The main conclusion of these qualitative studies was that the mull soils, in spite of the lower counts per gm., contain appreciably higher numbers of genera and species than the mor soils. The order *Mucorales* was studied most thoroughly, and within this order 22 species were demonstrated in mull soils and only 15 in mor soils.

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